
lbs
FULL HEAD OF STEAM
NOT BLOWING OFF
CORRECT WATERLEVEL
ON TIME
£'s
SAVED
GOOD FIREMANSHIP

GOOD FIREMANSHIP

British Transport Commission
(*Railways Division*) 1956

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WHAT THIS BOOKLET IS ABOUT

(1) Good Firemanship

The object of this booklet is not to lay down a rigid formula for the firing of steam locomotives, but is rather to give the fireman a better understanding of the principles involved in the management of his fire. Like the men who man them, engines have their own individuality, and they work under such varied conditions that it is virtually impossible to be precise as to how much coal should be put on the fire in a given period of time. But whatever the type of engine or work being performed, the best results are obtained by working systematically, and the pages that follow show the principles on which the system should be based, and the way the best firemen carry them out in practice on the road.

(2) The Steam Locomotive on British Railways

It may be thought that because the steam locomotive is being gradually replaced by other forms of traction, it is not worth while to concentrate on better methods of firing, but there are good reasons why this is not true. In the first place, the steam locomotive will remain of great importance to British Railways for many years to come, and secondly, during this transition period, coal is likely to become both scarcer and dearer. For these reasons it is in the interests of both the country and the railway industry to use as little coal as possible; and to give an idea of what savings can be made, tests show that if the average fireman improved his efficiency only half way to

that of the best fireman, then over a million tons of coal a year would be saved, and the railways would be over £4 million better off. All this adds up to the fact that many firemen are shovelling much more coal than they need, and the more efficient they are at the job, the less coal they use and the easier is the work. What is good for the country and the railways as a whole is good for the fireman as well.

THE HOW AND WHY OF FIRING

(3) Fuel for the Fire

All types of engines require fuel to provide the motive power and the amount is usually automatically regulated according to the amount of work being done. The steam locomotive is one of the few sources of power in which the fuel is added manually rather than automatically, and the skill of the fireman lies in regulating the amount of fuel for the fire so that it gives the maximum possible heat value. Just as petrol is fed to the internal combustion engine, so that it burns in the right place in the right amount and at the right time, so must the fireman feed his fire and appreciate what is necessary for good combustion.

(4) The Basis of Good Firing

Coal is the medium used to produce the heat necessary to generate the steam required to move the locomotive and its load, and the fireman therefore has two objects to fulfil; firstly, to burn each piece of coal so that it gives the maximum possible amount of heat, and secondly, to fire

sufficient coal to meet all the demands for steam that the driver needs for the work in hand. A thorough understanding of the best way to burn coal, and what demands the driver will make for steam, is the basis of the fireman's art, and the skill with the shovel that all good firemen develop does the rest.

The driver is as much a part of good firing as the fireman, for efficiency on the footplate is essentially the result of good team work. And as in all team work each can learn from the other, each is dependent on the other, and each can help the other. The driver with his close knowledge of the road, and accumulated experience of train working, can help the fireman, whilst the latter can anticipate the demand for steam and contribute just as much to good working.

(5) The Best Way to Burn Coal

The best way to burn coal is obvious to most of us, yet practised by few of us, even at our own firesides. But coal is laboriously won from the ground and dearly paid for so that whether as an individual or an industry we can ill afford to waste it. Whether in firebox or fireside, coal will only burn when it can combine with sufficient quantities of air, from both below the firebed to burn the solid carbon, and above the firebed to complete the combustion of the volatile gases given off by the coal. The amount of volatile gases varies according to the type of coal, being least in the Welsh varieties, but generally speaking all coal requires as much as twelve times its own weight of air for complete combustion. Too little air

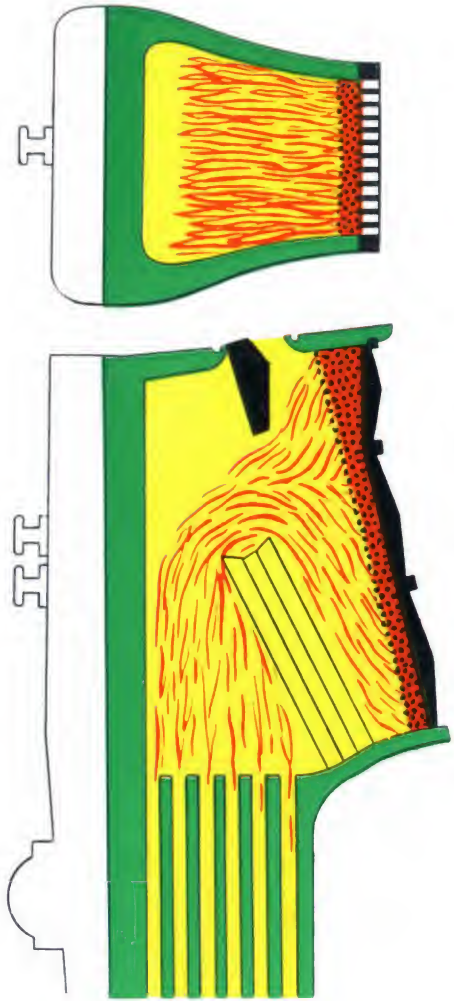
causes dense black smoke because of incomplete combustion of the volatile gases and too much air means that more heat is being lost up the chimney than need be. Complete combustion is a matter of finding the right balance between the coal and two sources of air—primary air through the ashpan and secondary air through the firebox door—and when this is achieved nothing more than a light grey smoke is visible from the chimney (Fig. 1).

(6) The Only Way to Keep a Good Fire

It is all a matter of obvious common sense at our own fireside—we never drown the fire with too much coal at one time, nor do we smother it with another pile before the last lot has had time to burn brightly away. If we (or someone else) do either of these things then we know that the result will be to sit and shiver before a smouldering black heap which is pouring black smoke up the chimney.

What happens in the firebox is only the same thing on a much larger scale, but until the pressure gauge starts dropping, the size and brightness of the fire tend to deceive the eye. When too much coal is being persistently thrown on the fire, the firebed increases in thickness so that enough primary air cannot get through to maintain a high enough temperature for complete combustion of the volatile gases, with the result that black smoke pours from the chimney.

The golden rule for keeping a good fire is, therefore, to limit the amount of coal fired at one time, and to restrict the rate at which each charge is fired, so that sufficient air is available to ensure complete combustion. In practice this means



Correct Fire

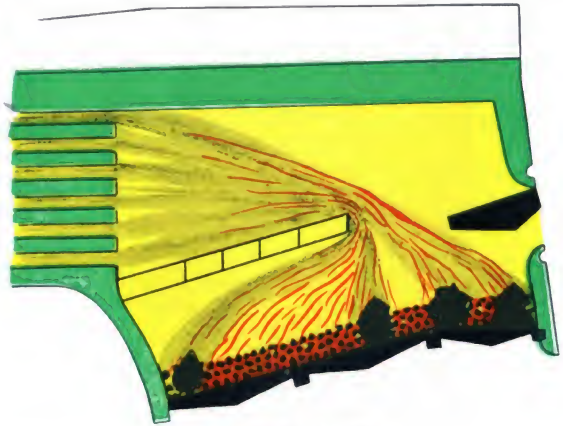
Firebed with even surface; no air holes, hollow places or dead patches; every square foot of grate doing its job; combustion space above firebed full of intensely hot flames; combustion completed in firebox.

FIG. 2

firing sparingly and evenly on to a firebed as thin and bright as possible, and waiting systematically until all the volatile gases have been given off and combustion is complete before firing again. Examples of " correct " and " incorrect " fires are shown in Figs. 2, 3 and 4.

(7) Firing for the Road

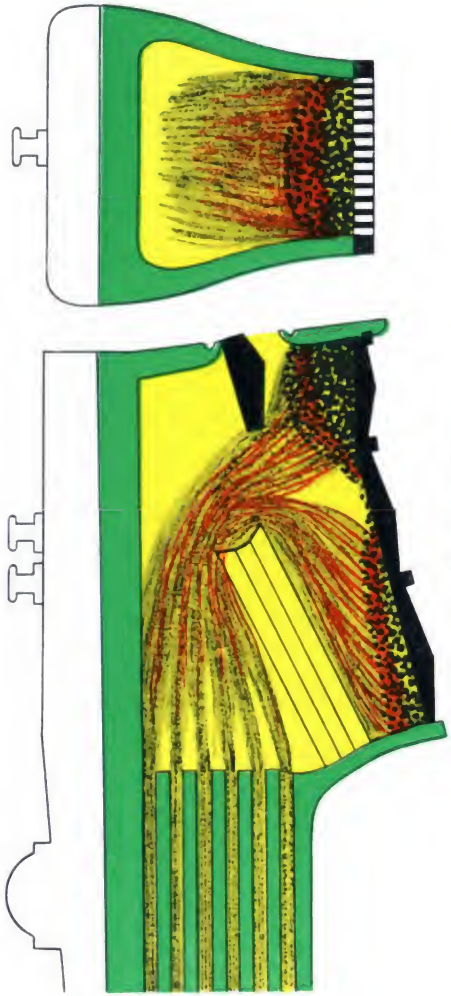
Firing on the footplate must not only aim to achieve complete combustion, it must also be carried out so that the right amount of steam is produced at the right time. This is where good firing depends so much on good team work between the driver, fireman, and time-table planner, as schedules are generally so arranged that the



Incorrect Fires

Large lumps of coal cause dead spots in firebed, gaps in flame stream and uneven firebed surface.

FIG. 3



Incorrect Fires

Firebed uneven; air unable to flow through thick patches under door and front of brick arch; too much air flowing through hollow patch and up to the sides of the firebox causing gaps in flames; combustion not completed in firebox; thick black smoke produced.

FIG. 4

demand for steam remains fairly constant. This is done by allowing for lower speeds on rising gradients than on the level or downhill, and so although the engine uses more steam per mile when climbing a bank, it uses little, if any, more steam per minute because it is moving more slowly. For example, supposing a train travels half as fast up a bank as it does on the level, then the pistons move half as fast, and the steam consumption would be halved if the rate of admission to the cylinders remained the same. However, in fact the rate of admission is usually increased by adjusting the reversing lever, but even if twice the amount of steam is admitted each time to the cylinders, the overall steam rate would be no greater because the pistons are only moving half as fast as on the level.

It is a mistake, therefore, to think that much more coal is required in a given space of time when travelling up rising gradients, so that there is no need to increase the rate of firing to any great extent. The more constant the rate of firing over the whole run, the more efficient the firing, and the less the coal consumption. However, this does not mean that there is no need to fire for the road, as intelligent anticipation of the route and the driver's requirements can be a great aid to efficiency.

(8) Firing on the Footplate

Because such a large amount of air—about twelve times—is necessary for coal to burn effectively, it follows that the amount and rate at which coal should be fired is very much less than many firemen realize. This has been proved conclusively, not only by scientific tests carried out to prove the best method of combustion, but also by observing the way the best firemen work in practice on the footplate. The best firemen burn the least coal because they burn it most effectively, that is by firing sparingly and evenly on to a bright fire, and by waiting systematically until the last lot has burned away before adding any more. On all classes of engine the most common mistake is overfiring, whether by large amounts haphazardly fired or by small amounts fired too often.

No hard and fast rules can be laid down about the exact amount of coal to be fired, and how often to fire it, because locomotives vary as much as the work they perform and the men who man them. However, for the larger locomotives the best results are found in practice to be achieved by not exceeding an average of twelve shovelfuls at a time, and by firing no more often than is necessary for good combustion. Smaller locomotives need proportionately less at a time, but the actual rate of firing will be found by simple observation for when too many shovels of coal are being persistently thrown into the firebox, black smoke will result and the thickness of the firebed will increase excessively.

THE WHEN AND WHERE OF FIRING

(9) Before Starting Away with the Train

No method of firing can give satisfactory results if the fire is in a poor condition at the start. There are three things to remember in preparing a good fire. Firstly, see that the firebars are free of clinker and ash by running the fire-irons along them, and if the coal is of a clinker forming nature add two or three shovelfuls of broken fire-brick or limestone.

EXCESS AIR, HEAT LOSS AND SMOKE.

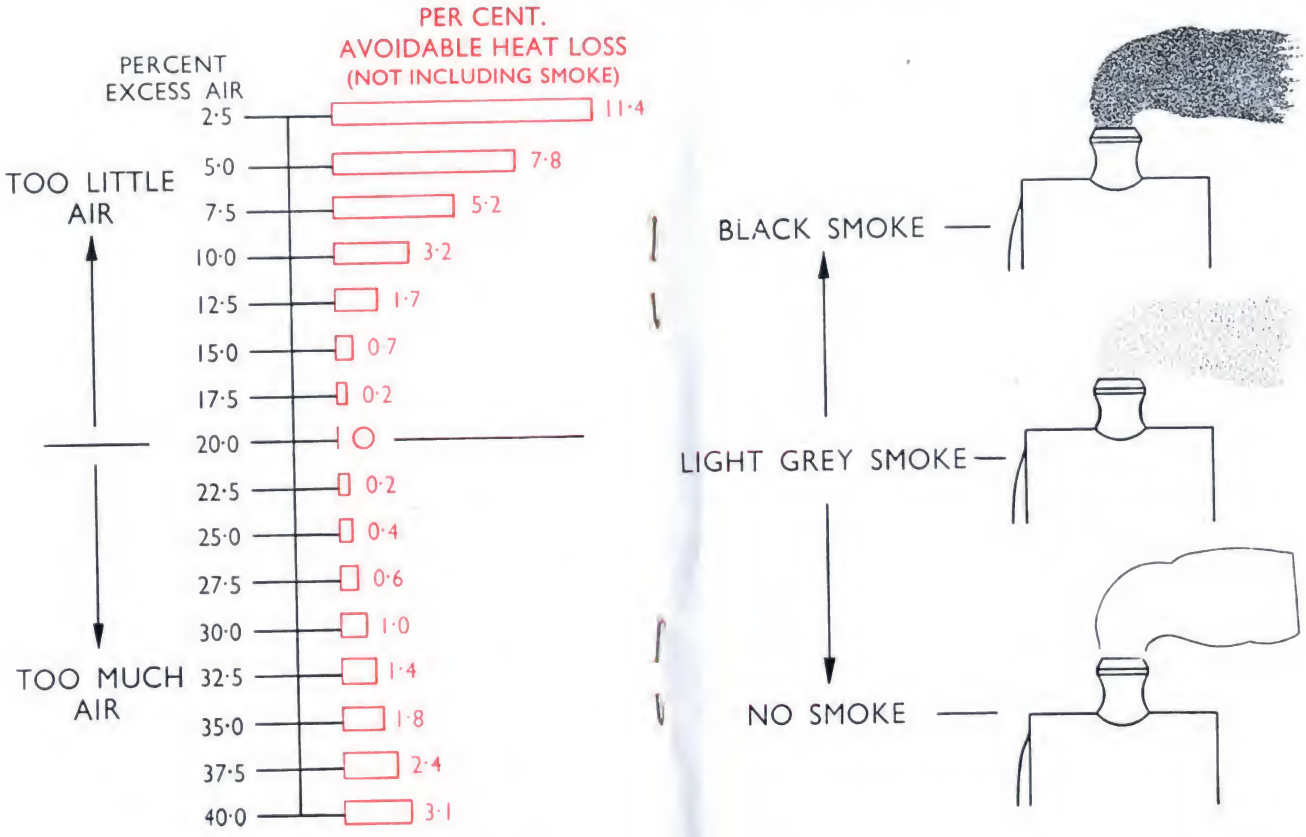


FIG. 1

Secondly, make sure that the fire is burning through evenly all over by filling in any hollow places; and thirdly, build the fire up gradually making sure that each layer of coal has burned through before adding any more.

This is the time to test and check the equipment on the locomotive, and to use the dampers and injectors to avoid wasting steam before it is needed. Test the injectors and arrange the boiler water level so that they can be applied to prevent blowing off whilst waiting to start away with the train. Finally, make sure the ashpan is clean, the smokebox door is screwed up tight, the fire-irons secure, and the coal properly trimmed on the tender.

(10) Starting Away with the Train

Never fire when the train is starting, but wait until you have moved a little way and the driver has notched up. This is because before the engine starts moving, the temperature of the firebed and brick arch is comparatively low, and the object is to raise it as quickly as possible so that the volatile gases are given off, and can combine with secondary air through the firehole door to produce more intense heat. When starting away, therefore, the firehole door should be partly closed, so that more primary air is drawn through the firebed and its temperature raised. When you begin firing add to the thinnest part of the fire first, and if the fire is being pulled into holes fill them up quickly.

(11) Firing on the Journey

Good firing on the journey is the result of a successful partnership between the driver, who by

skilful handling of the valve gear helps to keep the demand for steam constant, and the fireman, who by managing his fire efficiently maintains the boiler pressure. The steam rate remains fairly constant even when climbing gradients, because even when more steam is admitted each time to the cylinders, the pistons are also working more slowly per minute. This means that the rate of firing need not be increased to any great extent when climbing up rising gradients.

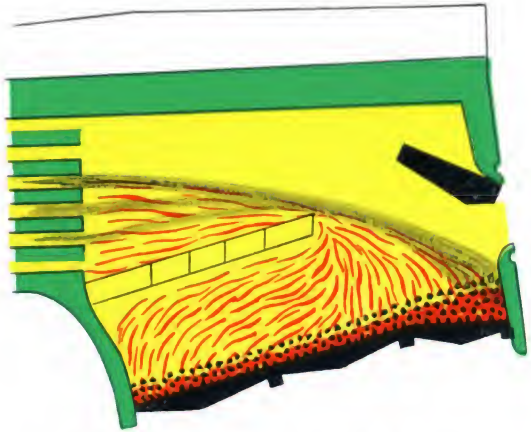
Firing for the road does not mean firing heavily for the hills, but anticipating the driver's requirements by managing the fire and injectors so that steam is available when it is wanted, but not wasted when standing or running downhill. For example, if the regulator is shut for a long period, ease down and stop firing before that point is reached; work the fire down when approaching the end of a run to avoid arriving on shed with too big a fire; and avoid firing where possible in stations and built-up areas where smoke is liable to cause a nuisance.

As the demand for steam is normally fairly constant a regular rate of firing gives the best results, especially when the amount is limited to to an average of not more than twelve shovelfuls at a time (less for smaller engines) and fired no more often than is necessary for good combustion.

Finally see that the deflector plate in the firehole door is placed so that it directs the secondary air down towards the firebed in order to mix thoroughly with the hot volatile gases and flames (Fig. 5); and break up large lumps of coal before firing them (Fig. 6), as otherwise they will stand up above the general level of the firebed and form a dead spot because they burn more slowly.

(12) When the Regulator is Closed

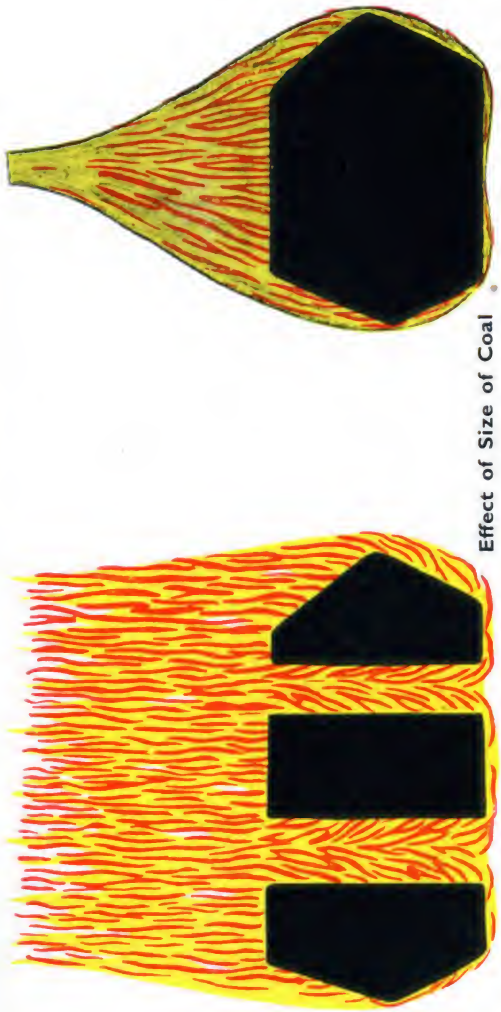
Avoid firing when the regulator is closed or about to be closed. The reason for this is, of course, that there is a time lag after firing the coal before the steam is produced, but once raised there is a definite limit to the amount that can be stored in the boiler. Every minute of "blowing off" means that coal is being wasted. Firing should also be confined to periods when the engine is moving, as the heat of the fire becomes less intense when the engine is stationary for any length of



Incorrect Position of Baffle Plate

Baffle plate tilted up allowing air to pass direct to upper part of tubeplate setting up strains, chilling nose of brick arch and laying foundations for dirty tubeplate and leaking tubes.

FIG. 5



Effect of Size of Coal

Many more surfaces are exposed when a piece of coal is broken: smaller pieces will cover a bigger area of the grate than a single lump and help to produce enough flame to fill the combustion space fully. Large coal should be broken down to about the size of a man's fist.

FIG. 6

time, and combustion is less efficient as a result. This applies particularly to freight working and shunting where the work may be intermittent, but also to passenger working when engines are standing in stations.

(13) It All Depends on Coal

The kind of fire you should keep depends upon the type of coal being used. All types of coal need sufficient air, but because the amount of fixed carbon and volatile gases varies, the primary and secondary air is needed in different proportions. South Wales coal contains more fixed carbon and less volatile gases so that the firebed needs to be fairly deep, and the firehole door partly shut because less secondary air is necessary. On the other hand, coal from the Midlands and North contains less fixed carbon and more volatile gases, and the firehole door needs to be wider open for good combustion.

Good quality large coal is not as plentiful as it used to be, and some lower grade coal must find its way into the firebox. It is more important than ever to get the best out of these lower grade coals, and that means applying the principles of good firing to them even more strictly, as only then will satisfactory working result, and the smoke nuisance be kept to a minimum.

THE PROOF OF GOOD FIRING

(14) Why Pick on the Fireman?

Very careful thought has gone into the problem of why coal consumption varies, both by those who are responsible for the design and building of

locomotives on the one hand, and those who are responsible for the maintenance and running of them on the other hand. There are, of course, many things to be taken into account such as the state of the engine, the weather, the load and the type of coal, but everything goes to show that probably the most important factor is the fireman himself.

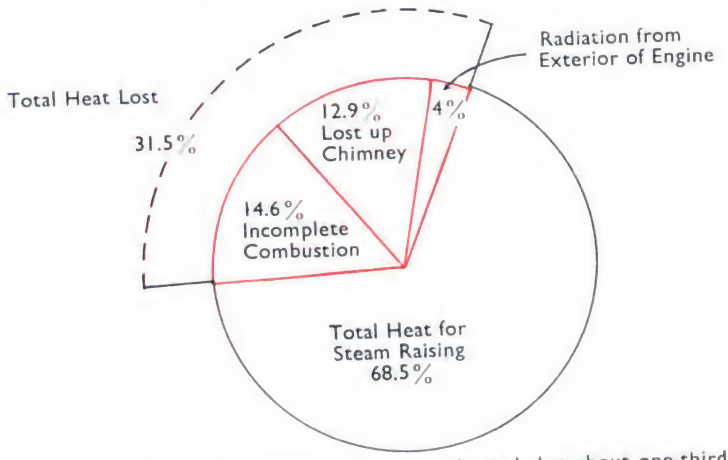
This conclusion has been reached not only as a result of scientific tests carried out to find out the real importance of achieving good combustion, but also by observing the way individual firemen put it into practice on the road.

(15) What the Scientific Tests Showed

The Research Department was called in to help to discover how the heat value of the coal was being used, and a series of dynamometer car tests was carried out over the same route, with the same load, and using the same type of locomotive, fired with the same kind of coal—only the fireman and the weather changed from day to day. The special dynamometer car used made a continuous analysis of the flue gases possible, and from this the efficiency of combustion could be measured. A typical result of one of these analyses showed that as much as a third of the heat value of the coal was being lost (Fig. 7).

The amount of coal being fired by individual firemen on the tests was found to vary considerably, and the flue gas analyses gave the clue that this might be due to differences in the efficiency of combustion. So it was decided to regulate the amount of coal put on the fire and find out how

How the Heat Value of Coal is Wasted



Special dynamometer car tests showed that about one-third of the heat value of the coal was being wasted.

FIG. 7

Less Coal — More Steam

Of twelve different firemen on the same run and in the same conditions, five " green " firemen used more coal and burned it less effectively than six " red " firemen who had their firing regulated scientifically to achieve better combustion. Only one of the six " green " firemen was burning his coal anything like as efficiently as is possible.

FIG. 8

much this affected coal consumption. The results showed that on the average an eighth less coal was used and that each pound of coal produced a tenth more steam. In other words, less coal meant more steam, and this was true of the unregulated firing just as much as the regulated firing, although the latter gave the better results (Fig. 8).

(16) What the Practical Tests Showed

In practice the fireman on the footplate has to find out for himself the way to burn the coal to best advantage. Extensive practical tests showed that the best firemen do not all fire exactly the same amount at precisely the same rate, even on the same type of engine, but they all observe the basic principles of good firing and so produce the most steam with the least coal and at the right time. The main lessons learned from the practical tests were that many firemen are burning far too much coal, either because they are firing irregularly and too heavily on the hills (Fig. 9), or regularly and too often for good combustion (Fig. 10). The difference between the best and the poorest firing was also found to be much greater than was expected, whilst the average firing was so far from the best that even a small improvement would be very well worth while.

(17) Blowbacks

When an engine is steaming normally a rate of burning is maintained which is proportional to the rate of steaming. Coal is consumed on the grate, and the gases produced are burnt above the fire in the secondary air stream which is drawn through the firehole door by the action of the exhaust steam passing through the blast pipe. This air

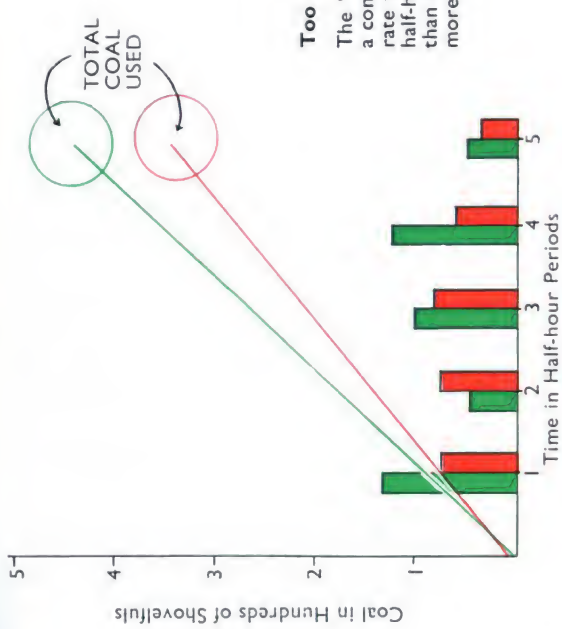
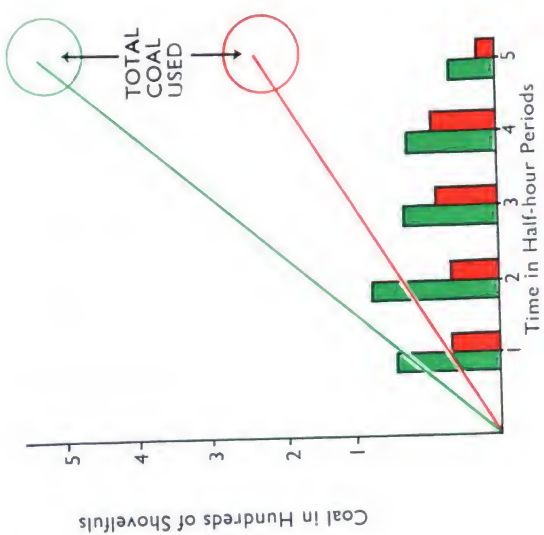


FIG. 9



Too Often—Too Much

Both firemen fired regularly but the "green" fireman fired too often and made black smoke for over half the journey. He used nearly twice the amount of coal and never had as good a boiler pressure as the "red" fireman because he never gave the coal enough time for complete combustion.

FIG. 10

stream can also be maintained by the action of the blower and it draws the flames and also the products of combustion towards the smokebox. If this air stream is interrupted, e.g., by closing the regulator, without opening the blower sufficiently, the combustible gases which are still being produced will be trapped in the firebox with two possible results:—

(*a*) Combustion may continue in the vicinity of the firehole door where air is still available. In these circumstances combustion will move towards this area, and flames will issue from the firehole door, producing what is known as a non-explosive blowback.

(*b*) Combustion may cease momentarily, and the gases then re-ignited from the firebed; this would produce an explosive blow-back with very rapid flame propagation and possibly more serious results, due to flames entering the cab.

Contributory factors to blowbacks are:—

(*a*) Hard coals and some briquettes with their distinctive long flames.

(*b*) Black fires which produce more combustible gases than can be consumed.

(*c*) Running bunker or tender leading with the damper immediately below the firehole fully opened. Combustion in these circumstances tends to be much more rapid in the vicinity of the air intake below the grate resulting in the emission of gases and the presence of flame in the vicinity of the open firehole door.

(*d*) Low tunnels and bridges may momentarily arrest the normal direction of the air-gas stream.

(*e*) A plate of the self-cleaning smokebox arrangement falling across the blast pipe due to insecure fixing.

The following points should, therefore, be borne in mind in order to avoid incidents of this nature:—

(1) Avoid black fires by overfiring, which besides wasting fuel produce excessive quantities of combustible gases.

(2) Always open the blower before closing the regulator, and also when approaching low tunnels, deep cuttings or bridges, especially when using hard coal or briquettes.

(3) Avoid using the trailing damper when running bunker or tender leading.

(4) During preparation ensure that all the self-cleaning equipment in the smokebox is securely fixed.

(5) When locomotives are working coupled together, and it is necessary to take water when passing over water troughs, the footplate staff in charge of the locomotive in the rear must take the additional precaution of seeing that the blower is open and the damper and firehole doors are in the closed position.

(18) Smoke Nuisance

Emission of smoke from locomotives is now very much in the forefront and is receiving consideration by the Government and Public Authorities. It is of

the utmost importance, in view of the grades of fuel now supplied to the Railways, that everything possible should be done to keep the emission of smoke to a minimum.

Excessive smoke, apart from being a waste of fuel, results in complaints from the public. Correct use of the dampers, blower and firedoor and the use of the firing technique already described, will reduce the emission of smoke to a minimum and avoid complaints.

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